(12) UK Patent Application (19) GB (11) 2 271 305 (13) A

(43) Date of A Publication 13.04.1994

(21) Application No 9221008.7

(22) Date of Filing 08.10.1992

(71) Applicant(s)
F & K Delvotec Bondtechnik GmbH

(Incorporated in the Federal Republic of Germany)

Raiffeisenallee 6, 8024 OBERHACHING,
Federal Republic of Germany

(72) Inventor(s)
Farhad Farassat

(74) Agent and/or Address for Service
Dibb Lupton Broomhead
Fountain Precinct, Balm Green, SHEFFIELD, S1 1RZ,
United Kingdom

(51) INT CL$^5$
B23K 1/00

(52) UK CL (Edition M )
B3R RAC R115 R300

(56) Documents Cited
GB 1260000 A

(58) Field of Search
UK CL (Edition L ) B3R
INT CL$^5$ B23K

# (54) Reflow soldering process control

(57) A reflow soldering process for mounting an electrical or electronic component on a substrate comprises supplying thermal energy to a lead 2 of the component, and the deformation of the lead is monitored and the level and duration of the supply of thermal energy is continuously controlled during the soldering process in response to the deformation of the lead.

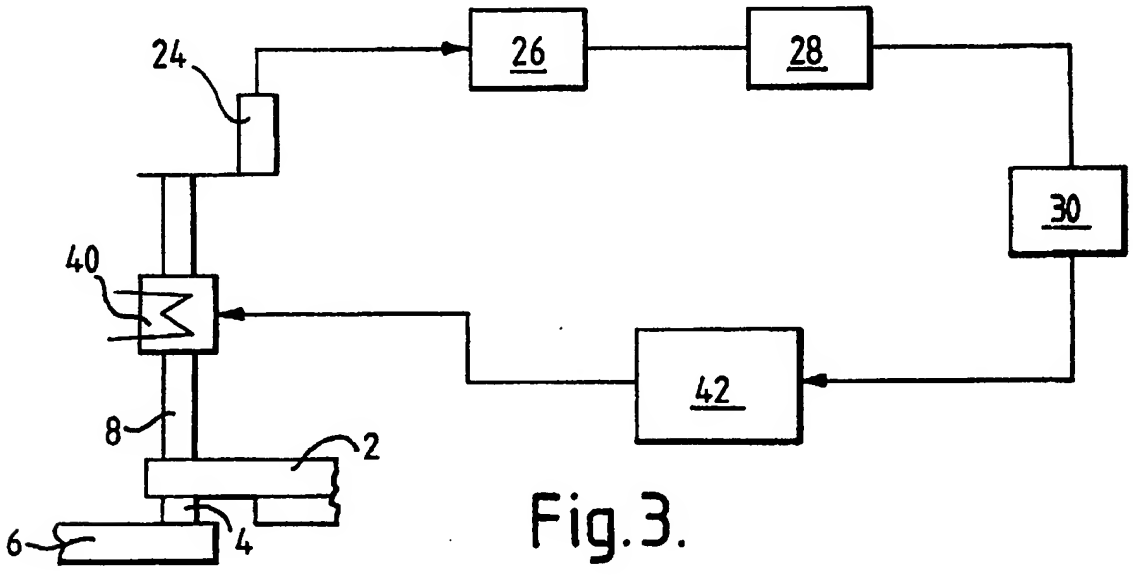


Fig.3.

GB 2 271 305 A

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

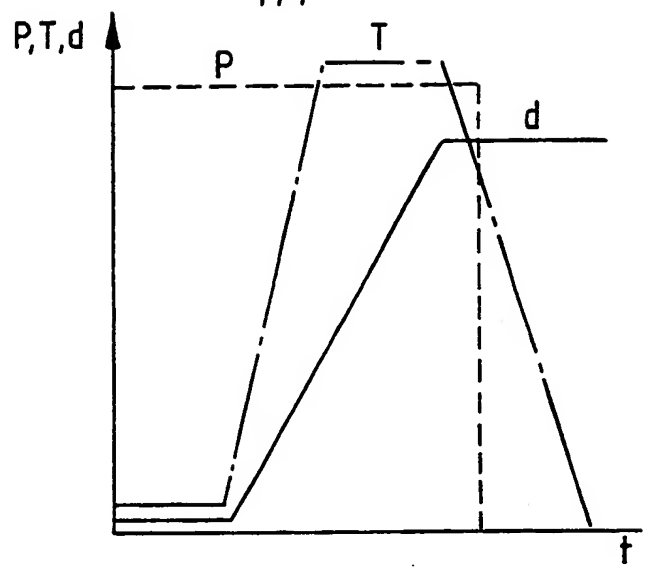


Fig.1.

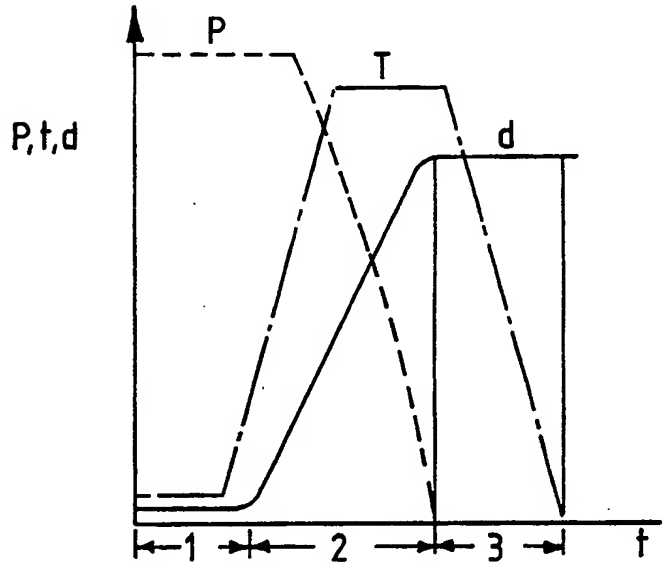


Fig.2.

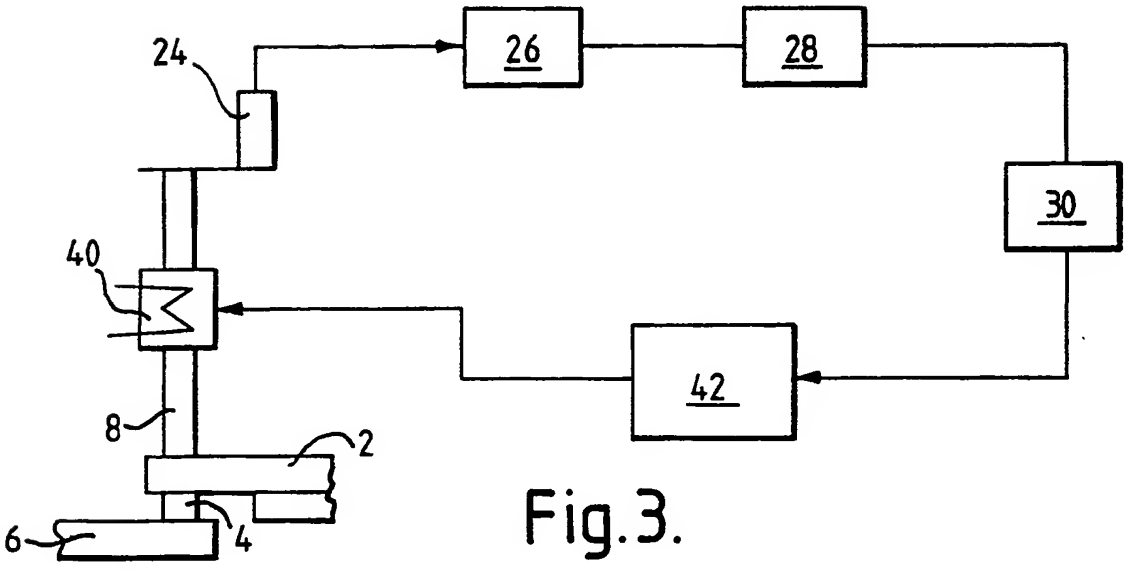


Fig.3.

2271305

# REFLOW SOLDERING CONTROL PROCESS

Reflow soldering is widely used for the mounting of electronic components such as resistors, capacitors, chip resistances and chip capacitors, on suitable substrates, in particular printed circuit boards (pcbs). Mounting techniques in which reflow soldering is used include surface mount technology (smt) and tape automated bonding (tab).

It is important in a reflow soldering process, particularly an automated reflow soldering process, to have as much control as possible over the process, and to be able to determine whether or not a solder has been successfully made. In particular, it is important to be able to ascertain whether a solder has been successfully made at the time of soldering rather than during a subsequent test routine. Because of the very rapid throughput of a reflow soldering apparatus, it would be advantageous if the soldering could be monitored immediately at the time of soldering, so that after the formation of an unsatisfactory solder the process can be stopped and the soldering conditions checked to prevent the production of a large number of unsatisfactory solders, with the consequent wastage of time and expensive components and materials.

Most reflow soldering machines currently in commercial use are only able to check whether a successful solder has been made after soldering is completed.

In the field of wire bonding, a number of methods have been proposed to check at the time of bonding whether or not a successful bond has been produced, including the method carried out using the apparatus described in the present applicants European Patent Application No. 0 368 533. The apparatus claimed in that specification comprises a bonding head comprising a bonding tool mounted on an ultrasonic transducer, a bonding tip of the tool being arranged, in the operation of the machine, to press aluminium wire against the contact surface of an electronic or electrical

component, the wire being drawn from a suitable wire supply, and a wire clamp by which the wire drawn from the wire supply may be clamped, the wire clamp being movable backward and forward generally in the direction in which the wire is fed appropriately to position the free end of wire drawn from the spool after completion of a bonding operation, characterised in that the automatic wire-bonding apparatus further comprises means for monitoring, during bonding, the quality of the bond formed between the wire and the surface to which it is to be bonded, by identifying those bonds which do not fall within predetermined maximum and minimum values for deformation of the wire due to ultrasonic excitation.

It is an object of the present invention to provide a method of controlling a reflow soldering process, in which the progress of the soldering process can be monitored at the time the solder is made. It is a further object of the present invention to provide a machine for carrying out that method.

The invention provides a method for carrying out a reflow soldering process for mounting an electrical or electronic component on a substrate, which process comprises supplying thermal energy to a lead of the component, characterised in that the deformation of the lead is monitored and the level and duration of the supply of thermal energy is continuously controlled during the soldering process in response to the deformation of the lead.

It has now been appreciated that the reflow soldering process is not, as has previously been assumed, a single stage process, but is in fact a two or three-stage process, each of which stages is advantageously carried out with the level of energy being supplied at that stage being specifically determined for that stage. In particular, it has been determined that the soldering process comprises a first stage, in which the solder is melted; a second stage

which is a reflow phase in which the lead is soldered to the substrate, and, a third cooling stage.

It has further been observed that each of these stages is advantageously carried out at a different energy level which can be empirically determined and controlled during the soldering process. It is in general found that the first, or melting, stage requires a relatively high energy level and takes place relatively rapidly; the second, or soldering, stage requires a lower energy level and the third, cooling stage requires the energy to be switched off in order to allow the system to cool.

While it is generally found that the energy levels required change as stated above, this is not necessarily the case and it is a particular advantage of the process according to the present invention that the soldering conditions are determined for each individual solder and optimised for that solder.

The third, cooling, stage may additionally comprise a positive cooling process, in which the cooling of the system is speeded up, for example by means of fluid cooling or gas cooling.

Suitable heaters for supplying thermal energy to the system include heaters which have a rapid effect, for example a pulsing heater with thermode, or a laser system.

Even successive solders formed using the same component and the same substrate may differ widely in their energy requirements, and by constantly monitoring the soldering process according to the invention, solders of a consistent high quality can be achieved with high efficiency, independent of any variations in the soldering conditions.

In a surface mount system, for example, variations in energy requirements typically arise because of differences in lead lengths and local differences in printed circuit board surfaces.

It is a further advantage of the method according to the invention, that the measurements taken not only monitor

deformation, but also confirm the presence of a solder pad and ensure that the positioning of the lead relative to the solder pad is correct.

The system according to the invention is thus an in-line closed loop system. An embodiment of the process according to the invention will now be described with reference to the accompanying drawings of which

Figure 1 is a graph showing lead deformation against time using constant energy (prior art);

Figure 2 is a graph showing lead deformation against time using energy controlled according to lead deformation and Figure 3 is a block diagram of an embodiment of apparatus suitable for carrying out the process according to the invention.

In Figures 1 and 2, the line P represents the graph of power against time; the line T represents the change in temperature with time and d represents the deformation of the wire against time.

In a prior art soldering process as shown in Figure 1, thermal energy (P) is supplied at a constant high level throughout the soldering process. The supply of a constant high level of energy without monitoring deformation, as in the prior art is inefficient in that it is wasteful of energy, may result in a reduction in the rate of throughput through the machine since energy is supplied to each solder for an excessive amount of time, and may also reduce the quality of the finished solder, since overheating may lead to a deterioration in quality.

In contrast to the prior art, as can be seen from Figure 2, in a method according to the invention, the graph shows three different zones which correspond to three different stages of the soldering process.

Zone 1 corresponds to a melting stage. Zone 2 corresponds to a soldering stage, and Zone 3 corresponds to a cooling stage.

In the melting stage, the energy requirement is high, since at this stage the solder is being brought into a molten phase.

In the second, soldering stage, the energy requirement is reduced, and the deformation of the lead is at a maximum. It is at this stage that soldering takes place.

The third stage is a cooling phase, in which the system is allowed to cool. Cooling may simply take place as a result of turning off of the energy, or positive cooling may be initiated by means of, for example, fluid or gas cooling.

The method according to the invention can suitably be carried out in apparatus as shown in schematic form in Figure 3.

The soldering apparatus comprises a tool 8 attached to a heater 40. The tool 8 is applied to a lead 2 which is positioned for soldering to a solder pad 4 on the surface of a printed circuit board 6.

A deformation sensor 24 is connected in a closed loop system to a deformation measuring 26 which is connected via a processor 28 to a regulator 30 which is itself connected to a heater control 42. The deformation sensor 24 is mounted directly above the bonding tool 8, and measures the downward motion of the tool.

The bonding tool 8 is also attached to a heater 40, preferably a pulse heater or a laser, which is driven by the heater control 42 connected to the regulator 30.

In operation, data from the deformation sensor 24 is fed via the deformation measuring system 26 to the processor 28 where the process is continually monitored and the required level of energy calculated. Data on the calculated level is then used to control the heater control 42 by means of the regulator 30.

The deformation sensor 24 and deformation measuring system 26 may be any suitable deformation system such as an

electronic system or an optical system, for example a laser system.

CLAIMS

1. A method for carrying out a reflow soldering process for mounting an electrical or electronic component on a substrate, which process comprises supplying thermal energy to a lead of the component, characterised in that the deformation of the lead is monitored and the level and duration of the supply of thermal energy is continuously controlled during the soldering process in response to the deformation of the lead.

2. A method according to claim 1 which is carried out as a three-stage process in which the first stage comprises melting, the second stage comprises soldering and the third stage comprises a cooling stage.

3. A method is claimed in claim 2 in which the cooling stage includes positive cooling of the system.

4. A method as claimed in any of claims 1 to 3 in which energy is supplied by means of a laser.

5. A method as claimed in any of claims 1 to 3 in which energy is supplied by means of a thermode from an impulse heater.

6. A method substantially as herein described with reference to the accompanying drawings.

**Examiner's report to the Comptroller under Section 17 (The Search Report)**

GB 9221008.7

**Relevant Technical fields**

(i) UK Cl (Edition L ) B3R

(ii) Int Cl (Edition 5 ) B23K

**Search Examiner**

D N P BUTTERS

**Databases** (see over)

(i) UK Patent Office

(ii)

**Date of Search**

12 JANUARY 1993

**Documents considered relevant following a search in respect of claims** 1-6

| Category (see over) | Identity of document and relevant passages | Relevant to claim(s) |
|---|---|---|
| A | GB 1260000 (FRY'S METALS) | |

| | | to claim(s) |
|---|---|---|
| | | |

**Categories of documents**

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

**Databases:** The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).